LOCAL ELECTRON FIELD EMISSION PROPERTIES OF THE NANODIAMOND FILMS MEASURED USING SCANNING TUNNELING MICROSCOPIC TECHNIQUE

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Abstract

Diamond films, which can be synthesized easily by using microwave plasma enhanced chemical vapor deposition (MPECVD) process have been extensively investigated for the applications as electron sources, since they possess very consistent and good electron field emission properties[1]. However, the electron field emission properties of the diamond films are still pronouncedly inferior to those of carbon nanotubes (CNTs). Therefore, there have wide interest in improving the electron field emission properties of diamond films recently. One of the possible routes for increasing the electron field emission capacity of diamond films is to increase the proportion of grain boundary region, as it has been proposed that the grain boundaries contain sp^2-bond and provide conduction path for electrons, facilitating the electron field emission process[2]. In this paper, we adopted the bias enhanced technique for synthesizing boron-doped nanodiamonds. The electron field emission properties of the nanodiamond films were examined using scanning tunneling microscopic (STM) technique. Current image tunneling spectroscopic (CITS) measurements reveal the direct dependence of electron tunneling/field emission behavior of the films on the proportion of grain boundaries contained in the films. Local tunneling current-voltage (I_t-V) measurements show that incorporation of boron species insignificantly alters the occupied state, but markedly modifies the empty state of the diamond films, viz. it induced the presence of impurity states for the films heavily doped with borons, resulting in smaller emission energy gap for the samples. Such a characteristic improves both the local electron field emission behavior of the diamond films measured by STM and the average electron field emission properties measured by conventional parallel plate setup. These results infer clearly that the presence of impurity states due to boron doping is a prime factor improving the field emission properties for these boron-doped nanodiamond films.

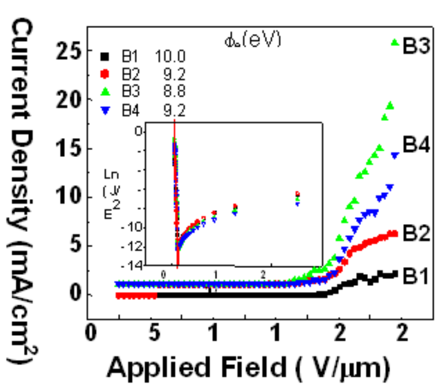

Fig. 1 Eelectron field emission properties of nano diamond films doped with 1-4 sccm $B(OCH_3)_3$ species, which were designated as B1-B4 (the inset shows Fowler-Nordheim plots of the I-V curves).

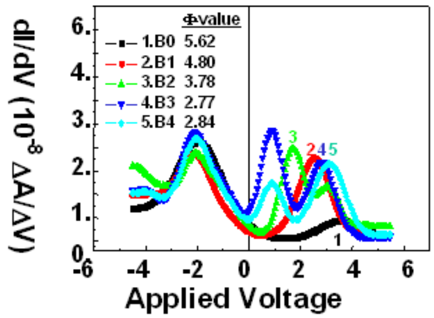

Fig. 2 The derivatives of tunneling current, dI_t/dV-V, for boron-doped nanodiamond films measured by STM techniques with tip-to-film gap set to at 1 nm.

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